Support building materials with low embodied greenhouse gas emissions as way to keep working forests as forests

Background: Embodied Greenhouse Gas Emissions are the emissions associated with the extraction, processing, transportation, construction and disposal of materials. It is very closely associated with embodied energy, which aggregates the total amount of energy used in the above-mentioned stages. Until fairly recently it was assumed that embodied energy/embodied GHG emissions of building materials were minimal compared to the energy used during the operational life of a building. However, numerous studies have concluded that embodied energy of building materials are equivalent to many years' worth of operating energy. For example, Perez-Garcia et al (2005) found that embodied energy accounted for over 10% of the total energy consumed during the life of a house. Australia's Commonwealth Scientific and Industrial Research Organization (CSIRO) found that embodied energy is equivalent to roughly 15 years of operating energy (Reardon et al 2005). This impact becomes more significant as efficiency increases in operating energy.

Proposals for encouraging use of building materials with low embodied greenhouse gas emissions

1) Incorporation of LCA into green building standards

There are a number of life cycle assessment (LCA) tools that can look at the embodied energy, along with other environmental impacts such as toxic releases to air, toxic releases to water and solid waste, of materials used during building construction. These tools have been incorporated into some green building rating systems[1], but not all.

Currently Washington State has a number of legislative requirements for exclusive use of Leadership in Energy and Environmental Design (LEED) Green Building Rating System in public buildings.[2] The LEED system does not include embodied greenhouse gas emissions, but a proposal, "LCA into LEED" is being worked through the U.S. Green Building Council's Material Resources group. There are plans to start a pilot program in the fall of 2008 and submit for balloting after the USGBC is confident the program can work (expectation this will be at least 12 months).

Proposed Recommendation 1: Washington State should strongly urge USGBC to adopt the proposed "LCA into LEED," or adopt legislation that encourages consideration of embodied greenhouse gas emissions in green building standards.

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[1] Building Research Establishment (BRE) Green Guide to Specification (http://www.thegreenguide.org.uk/) has been using a life cycle assessment (LCA) environmental profile tool for over a decade. The Green Globes environmental assessment and rating system for commercial building launched a LCA environmental profile tool in 2007..

[2] Executive Order 05-01 requires LEED silver standards for public buildings in Washington. The state's High-Performance Public Buildings law (Chapter 39.35D RCW) requires all new state-funded facilities over 5,000 sq. ft. to meet green building standards, with specific requirements that major office and higher education facility projects achieve LEED Silver certification. In addition, all new K-12 schools are required to meet either the Washington Sustainable Schools Protocol (WSSP) or LEED certification.

2) Revisions to the state building code
Chapter 19.27A RCW[3] requires amendment of the state building code to address energy efficiency, but the statute does not require consideration of embodied greenhouse gas emissions.

Proposed Recommendation 2: Legislation should be adopted which requires the state building code council to adopt revisions of the state building code which allow and encourage the substitution of low embodied greenhouse gas materials (e.g. wood and agricultural products) for building materials with higher embodied greenhouse gas emissions, where product substitution is consistent with promoting the health, safety and welfare of building occupants and users and the public generally.

3) Allowance for the use of low embodied greenhouse gas building materials as a potential mitigation measure under SEPA

Proposed Recommendation 3: Legislation or regulations should be adopted providing that the impacts from embodied greenhouse gases should be considered in environmental reviews of construction projects conducted under the State Environmental Policy Act (SEPA) and that substitution of wood and agricultural products for construction materials with higher embodied greenhouse gas emissions should be considered under SEPA as a potential mitigation measure for adverse climate impacts. The ATHENA EcoCalculator, which is used to determine average embodied emissions in the King County SEPA GHG Emissions Worksheet Version 1.7 (12/26/07)[4] can be used to quantify the emissions savings by using low embodied emissions materials (see LCA tools background for more information)

4) Carbon labeling of building materials
Currently a consumer has no way of knowing the relative greenhouse gas emissions associated with the material, manufacturing, and transportation of the products they buy.

Proposed Recommendation 4: A carbon labeling scheme would indicate to the consumer the total embodied carbon greenhouse gas emissions during the life cycle of a particular product. The design of effective labels and systems should avoid being unduly burdensome and should build off of existing programs wherever possible. Life cycle assessments have already been done on many building materials (e.g. see ATHENA's EcoIndicator calculator) and, in the beginning, these results can be included in literature without having to do extensive LCAs on individual products. Eventually a carbon labeling program could be developed to include participation by manufacturers and product lines.

[3] http://apps.leg.wa.gov/rcw/default.aspx?cite=19.27A
[4] Available at: www.metrokc.gov/ddes/forms/SEPA-GHG-EmissionsWorksheet-Bulletin26.pdf

Additional background:

Studies that compare embodied greenhouse gas emissions of various building materials.

Study	*Wood* *(kg CO_2/m^2 living space)*	*Concrete* *(kg CO_2/m^2 living space)*	*Concrete vs. Wood (% Change)*
Noren, J. 2001.	30	400	1233%
Trusty, Meil 1999			
Meil et al 2002	280	420	50%
Glover 2001	290	510	76%
Buchanan and Levine 1999	220	345	57%
Borjesson and Gustavsson 2000[5]	~40	~60	~50%

Study	*Wood* *(kg CO_2/m^2 living space)*	*Steel* *(kg CO_2/m^2 living space)*	*Steel vs. Wood (% Change)*
Trusty, Meil 1999	280	340	21%
Meil et al 2002	207	309	49%
Glover 2001	290	690	137%
Buchanan and Levine 1999	220	352	60%

On a large scale, the selection of building material makes a significant difference. For example:

- If 1.5 million housing starts in the U.S. used wood-framed houses rather than non-wood building systems, 9.6 million metric tons (mt) CO_2e per year would be kept out of the atmosphere. This savings is equivalent to keeping roughly two million cars off the road for one year (Miner et al, 2006)
- Using wood-framed housing in the 1.7 million housing starts in Europe[6] would save 35-50 million mt CO_2e, which would be enough to contribute 11-16% of the emissions reduction needed for Europe to meet the Kyoto requirement (Eriksson 2003).
- A 17% increase in wood usage in the New Zealand building industry could result in a reduction of 484,000 mt CO_2e. This reduction is equivalent to a 20% reduction in carbon emissions from the New Zealand building industry and roughly 2% of New Zealand's total GHG emissions (Buchanon and Levine 1999).
- Goverse et al (2001) concluded that an increase in the use of wood could cut CO_2 emissions from construction by almost 50% compared to Dutch traditional construction.

[5] Converted from whole building (apartment building with 1040 m^2 living space) to per m^2 living space
[6] Currently only 5% of new construction in Europe uses wood framing

LCA Tools
ATHENA EcoCalculator[7]- The ATHENA EcoCalculator for Assemblies compiles greenhouse gas emissions for different material building assemblies (e.g. exterior walls, roofs, windows, floors, interior walls) based on detailed life cycle assessments using the ATHENA Impact Estimator for Buildings. The ATHENA Impact Estimator, in turn, uses data from the US Life Cycle Inventory Database and ATHENA's own datasets (see http://www.athenasmi.ca/tools/docs/EcoCalculatorFactSheet.pdf for more detail). The EcoCalculator is used by architect firms and universities and can be used for new construction, retrofits and major renovations in industrial, office or residential design.

The ATHENA EcoCalculator calculates the average embodied greenhouse gas emissions, *per square foot (square meter)*, for each building assembly[8]. This then can be scaled up to the square footage of an average house. A builder can then enter the square footage of a particular material assembly type that will be used in the building. The embodied greenhouse gas emissions will be automatically calculated in ATHENA and summed across all assemblies (e.g. floor, interior wall, exterior wall, roof, windows).

The difference in embodied greenhouse gas emissions between the average building assembly and the builder's assembly can be readily quantified.

Here is what the ATHENA EcoCalculator looks like

EcoCalc_Vancouver_CAN_Low-Rise_v2(1).3

ATHENA® EcoCalculator for assemblies

TOTAL IMPACTS BY BUILDING COMPONENT	Primary Energy (MJ) TOTAL	GWP (tonnes) TOTAL	Weighted Resource Use (tonnes) TOTAL	Air Pollution Index TOTAL	H2O Pollution Index TOTAL
COLUMNS & BEAMS	0	0	0	0	0.00
INTERMEDIATE FLOORS	0	0	0	0	0.00
EXTERIOR WALLS	0	0	0	0	0.00
WINDOWS	0	0	0	0	0.00
INTERIOR WALLS	0	0	0	0	0.00
ROOF	0	0	0	0	0.00
WHOLE BUILDING	0	0	0	0	0.00

E. INTERIOR WALLS

ATHENA ASSEMBLY EVALUATION TOOL v2.3—Vancouver Low-Rise Building

IN THE YELLOW CELLS BELOW, ENTER THE AREA (in m^2) THAT EACH ASSEMBLY IS USED IN YOUR BUILDING

	ASSEMBLY TYPE	m^2	Percentage of total	Primary Energy per m^2 (MJ)	GWP per m^2 (kg)	Weighted Resource Use per m^2 (kg)	Air Pollution Index per m^2	H2O Pollution Index per m^2
Average:				629.42	27.78	111.63	8.02	0.0136
1	Wood stud (16" OC) gypsum board + latex paint each side	0		316.13	8.74	90.12	3.83	0.0000
2	Wood stud (24" OC) gypsum board + latex paint each side	0		309.41	8.58	86.01	3.79	0.0000
3	Wood stud (24" OC) gypsum board x2 + latex paint each	0		500.21	15.11	134.39	6.58	0.0000
4	Steel stud (16" OC) gypsum board + latex paint each side	0		377.09	14.23	87.12	4.47	0.0426
5	Steel stud (24" OC) gypsum board + latex paint each side	0		354.54	12.68	83.41	4.27	0.0325
6	Steel stud (24" OC) gypsum board x2 + latex paint each	0		545.34	19.21	131.79	7.06	0.0325
7	6" Concrete block; gypsum board + latex paint each side	0		975.29	53.42	163.10	11.96	0.0135
8	6" Concrete block; latex paint each side	0		784.49	46.88	114.73	9.17	0.0000
9	Clay brick (4") unpainted	0		1502.32	71.21	114.02	21.01	0.0011
	TOTAL m^2	0.00						

COLUMNS AND BEAMS / INTERMEDIATE FLOORS / EXTERIOR WALLS / WINDOWS / **INTERIOR WALLS** / ROOFS

[7] Available free of charge at: http://www.athenasmi.org/

[8] Note: this average should not be a weighted average based on current market share but rather the physical average of different options of assembly types. It is important to recognize that current market share today does not lock-in current market share in the future, and the benefits should actually accrue to the lowest carbon footprint materials.

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